MDE Product Development Team
FY13 4th Quarter Report
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(Compiled and edited by S. Benjamin and B. Johnson)

Executive Summary

Task 1: Improve turbulence guidance from NWP forecasts

- RAPv2 continued in parallel testing on WCOSS by NCEP/EMC over entire quarter and by NCEP/NCO starting in October. New comparisons between RAPv1-operational and RAPv2 parallel for 1h and 6h forecasts show improvement from RAPv2 for wind, temperature and humidity forecasts at nearly all altitudes.
- RAPv2 implementation at NCEP replacing RAPv1 is still currently scheduled for Q1 FY14 (December 2013).
- New parallel RAP test with 0.75 weights for ensemble background error covariance (vs. variation) in hybrid assimilation gave further improvement to wind forecasts (component for RAPv3).
- RAPv2 summer 2013 configuration implementation continues to run smoothly on Jet (Boulder, RAP primary cycle) and Zeus (Fairmont WV) supercomputers and initializing experimental HRRR.
- Three real-time parallel RAP cycles (with extensive verification of each) running on Zeus NOAA research supercomputer located in Fairmont, WV to evaluate further likely enhancements to RAP data assimilation / model system for spring 2014 code freeze.
- NCEP making continued progress on NAM and NAM-nest

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Internal evaluation of the 2013 HRRR completed, indicating improvements over 2012 HRRR and reliability ~95% benefitting from primary and parallel runs of HRRR on jet and Zeus NOAA computers this year.
- Modification to real-time ESRL HRRR (and RAP) to correct error in coupling of land surface model to boundary layer scheme that was producing slightly high dew point bias for certain situations.
- Retrospective evaluation of combined 13-km RAP / 3-km HRRR radar reflectivity assimilation impact and work toward evaluation of 3-km HRRR radial velocity assimilation impact.
- HRRR infrastructure installed on NCEP WCOSS computer and testing underway with implementation tentatively scheduled for Q2 FY14 (Mar 2014), following the RAPv2 implementation planned for Q1 FY14 (Dec 13).

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

- Same updated physics configuration now running in both RAPv2 at GSD and in parallel cycle on WCOSS machine at NCEP [MYNN boundary-layer scheme (Olson version), 9-level PBL, updated Thompson microphysics, others]
- Further improvements to MYNN PBL scheme are producing improved near-surface winds, planned for late 2013 implementation into ESRL RAP (RAPv3) and HRRR.
- Upgraded Grell-Freitas deep and shallow convection scheme in renewed testing in RAP at GSD, breakthroughs in October with likely implementation in RAPv3.
- Important fix made to canopy evaporation in RUC LSM when MYNN boundary-layer scheme is used.

Task 4: Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA

- Real-time, frozen RAPv2/HRRR system running successfully with gridded field dissemination, real-time web display of graphics and verification of many forecast fields.
- Ongoing monitoring of RAPv2/HRRR system with regards to reliability (including joint reliability with Jet – Zeus failover) and forecast performance.
- HRRR "failover" capability to use feed from Zeus instead of Jet during Jet downtime is working; enhancements necessary to make Zeus completely independent of Jet will come in July.
- Examination of enhanced verification of HRRR convective forecasts, including VIL and echo-top.

Task 1: Improve turbulence guidance from NWP forecasts

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).

Tasks will include:

- Continuing evaluation of RAPv2 toward early 2014 implementation at NCEP, incorporating changes developed in 2012 and early 2013
- Development of RAPv3 toward 2014 implementation at ESRL and subsequent implementation at NCEP
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

ESRL

Regarding the operational NCEP RAP

The switchover from the old IBM Power 6 machines to the new Weather and Climate Operational Computing System (WCOSS) at 12Z 25 July 2013 went smoothly for the RAP as well as other NCEP operational models including NAM. GSD thanks Geoff Manikin, Dennis Keyser, Geoff DiMego and others at EMC and NCO for their efforts to ensure this major transition went smoothly. GSD participated significantly in the transition to solve technical issues, primarily through Ming Hu. Other than minor disruptions due to the switchover, the operational RAP at NCEP continues to run without any technical problems, including post processing.

Progress toward RAPv2 implementation at NCEP

- RAPv2 implementation remains scheduled for 17 December 2013 despite the furlough in early October. NCO successfully started a RAPv2 parallel cycle in October. GSD (esp. Ming Hu) and EMC (Geoff Manikin) solved further technical issues with the NCO implementation of RAPv2.
- Three bug-fix changes were made to the NCEP/EMC version in final testing before the planned implementation in December. To maintain consistency with the exact same code between NCEP and ESRL RAPv2-primary versions, the same changes were made to the ESRL RAP. These code changes were made to the ESRL RAP-primary on 10 September 2013:
    - In late August, a significant bug was removed in the RUC LSM as a result of a renewed search for the cause of unrealistically large latent heat fluxes in cloudy regions. The culprit was excessive canopy water evaporation when the RUC LSM is coupled with the MYNN boundary layer and surface-layer scheme. This problem only manifested where precipitation had recently occurred, and its correction removed a moist bias in 2-m dew point and often-excessive surface-based CAPE values in such regions. This fix was incorporated into the EMC RAPv2 code as well as in the RAP-primary and dev1 cycles at GSD since it was necessary to match needed bug-fix changes to the NCEP/EMC RAPv2, also in final evaluation prior to the implementation in a few months.
    - The unusual case study problem with excessive snowfall in the RAP over the Omaha area on 2 May 2013 discussed in the FY2013-Q3 report was further investigated and found to be related to the conversion of radar reflectivity to snow mixing ratio using a procedure consistent with the Thompson microphysics scheme—when there are lots of small snow particles, even moderate reflectivity's can lead to excessive snow mixing ratios. To preclude this from happening in the future, the snow mixing ratio from the GSI hydrometeor analysis is now restricted to be no larger than 3 g/kg. This change was included into the RAPv2 (both ESRL and NCEP/EMC) on 10 Sept 2013.
    - Closer examination of lake surface temperatures during the summer prompted in part by National Weather Service Western Region forecaster queries regarding excessive lake breezes off some western lakes in the HRRR led to changes in our use of the NAM and global SST files from NCEP for the lake surface temperature of fresh-water lakes. Now we use the global SST for the Great Lakes, but use the NAM SST for smaller lakes over the West. Also, we have returned to the use of climatological SST for Great Salt Lake and the Salton Sea, as well as Lake Champlain (as used previously in the RUC).

- Summer and winter 30-day retrospective experiments were completed on the Zeus computer using the same code as has been running in the EMC RAPv2 parallel cycle since early September. The dates of these retros are 26 Jan – 26 Feb 2013, and 15 May through 15 June 2013. When compared with NCEP RAPv1 forecasts for these retro periods, these retrospective tests show substantial improvement in wind forecasts, particularly at lower altitudes, and overall similar or improved skill in temperature and humidity forecasts. An exception is a summertime warm and dry bias in 2-m temperature and dew point during late morning and afternoon in areas of clear skies over the CONUS. Ongoing work to address this issue is discussed further below and under Task 3. In addition, intensive real-time comparisons of the now identical GSD RAP-primary and EMC parallel (EMC RAPv2) are ongoing.
- Grids from the EMC RAPv2 parallel cycle started to being verified at GSD as of 2 September, after efforts by GSD and NCEP to ftp needed grids to ESRL. Fig. 1 shows improved performance of the EMC RAPv2 parallel relative to the operational RAPv1 for the first half of September. This is evident for both 1 and 6-h forecasts for nearly all altitudes from the surface to 100 hPa, and for wind, temperature and relative humidity, as anticipated from earlier comparisons of the GSD RAP-primary cycle with the operational RAPv1 shown in earlier reports.
- On 14 August, Stan Benjamin, with help from Geoff Manikin (NCEP/EMC), gave a new update on RAPv2 and HRRR science status to NCEP management at a WCOSS Science Quarterly review meeting – ppt available here **http://ruc.noaa.gov/pdf/EMC_RAPV2_Upgrade-HRRR-final-14aug2013.pdf**. This PowerPoint gives a good summary of the differences between RAPv2 and RAPv1.

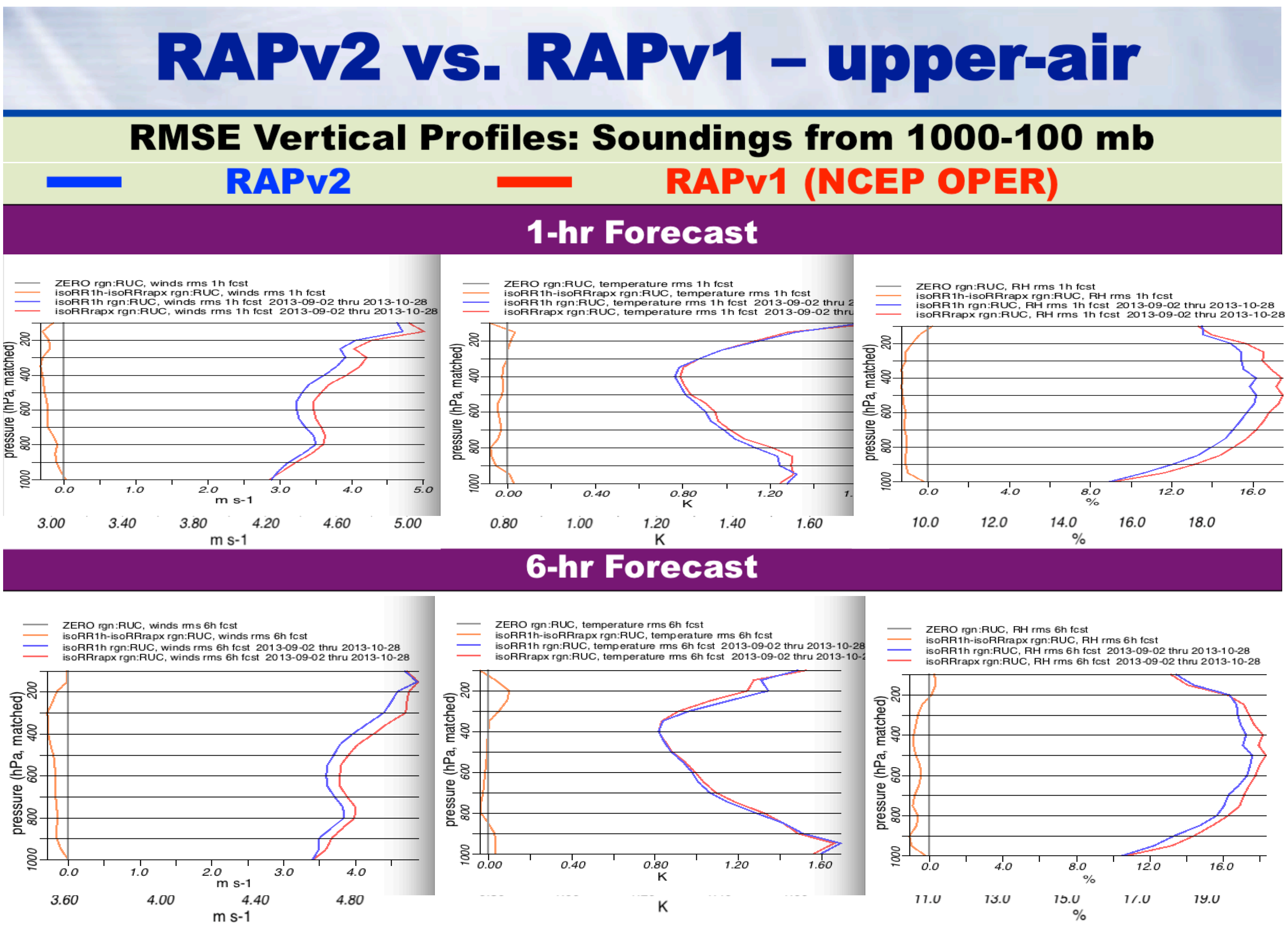


Figure 1. Verification of RAPv2 (ESRL) vs. RAPv1 (NCEP operational) forecasts vs. rawinsonde observations for 2 Sept – 27 Oct 2013 for 1h and 6h duration for wind (left), temperature (center), and RH (right). Line further to left shows smaller error and more accurate forecast.

RAPv3 data assimilation testing (reported in July 2013)

- Ming Hu ran a new 1-week parallel warm-season test with a modification to the hybrid ensemble/variational data assimilation, now using a 0.75/0.25 weighting of ensemble vs. fixed background error covariance instead of the current 0.5/0.5 weighting. This result gave improved upper-level wind forecasts, and if this result is also found in a later cold-season test, this modification would be included in future versions of the RAP at ESRL (implemented by Jan-Mar 2014), where it will also improve the ESRL HRRR. It also will be included in the subsequent (can be called "RAPv3") version at NCEP.
- Another parallel test was run with mesonet observations added (Patrick Hofmann). Results showed slightly better surface wind forecasts and slightly poorer 2m temp forecasts. A new study will next test a further mesonet assimilation impact test but now using a much improved observation use list (developed by Bill Moninger) and modified GSI code to use this modified use list (by Xue Wei), to be run again by Patrick Hofmann.
- Patrick Hofmann made additional parallel tests for full-column cloud building using the GOES CLAVR-X effective cloud amount. (Still better results in avoiding the previous mid-tropospheric moist bias that plagued previous full-column satellite-based cloud building). This change appears to be ready for RAPv3.

RAPv3 model testing

- With the release of WRFv3.5.1 by NCAR on 23 September, Tanya Smirnova began work toward merging the unique RAP features at the top of the WRFv3.4.1 trunk to v3.5.1. This went fairly smoothly, and the RAP-dev2 and dev3 on Zeus are running with this version since 21 October.
- Revision and evaluation of the Grell-Freitas convective scheme and its related shallow convection scheme was the subject of much effort in October, related to subsequent updates in RAP-dev2 and RAP-dev3.
- Parallel testing continues toward improving the MYNN boundary-layer scheme. Now that the canopy-water evaporation bug has been fixed, efforts are now directed toward reducing the warm and dry bias during daytime under clear skies (see Task 3).
- Tanya Smirnova continues to investigate changes to the RUC LSM relating to surface roughness length over snow (see Task 3).
- A new precipitation-type verification is being tested with retrospective and real-time RAP and HRRR output. Also a problem with RAP verification on the Alaska Grid 242 (Polar Stereographic) was fixed (Bill Moninger).

Other activities, some noted more fully under other tasks, also were undertaken:

- Retrospective testing for both RAP and HRRR of the impacts of proprietary in situ tower wind data and other special data continued under funding from the DOE Wind Forecast Improvement Project.
- Discussions with EMC are underway concerning the best procedure to ensure that proprietary wind tower and nacelle wind measurements are available to the operational RAP and NAM now that WCOSS has come online.
- Biweekly telecons between GSD and the Storm Prediction Center of NCEP continue to be very beneficial. The purpose of these telecons is to obtain feedback from SPC on RAP (RAPv2 from GSD as well as the operational v1) and GSD HRRR-primary performance, to give SPC opportunity to comment on our ongoing RAP and HRRR development work, and to inform SPC of planned Jet and Zeus computer downtimes.

NCEP

Rapid Refresh V2 ran in parallel during the entire quarter. The WCOSS platform has become more stable, so this parallel ran more reliably than in the previous quarter, allowing meaningful statistical results to be obtained. Unfortunately, changes made to the WCOSS job scheduler in September caused the RAPv2 parallel to become slightly less reliable. As a result, NCO has agreed to start running the parallel on the production machine and work is underway to assist NCO in building their parallel system, with an expected completion date in the middle of October. The operational RAP crashed on 17 September. The problem was traced back to the code reading in boundary conditions every 6 hours instead of every 3, because it wasn't compiled correctly on WCOSS. The code was successfully recompiled on 24 September. Work continued on building the High-Resolution Rapid Refresh (HRRR) at EMC on WCOSS (Curtis Alexander of GSD with EMC). The major codes (analysis and prediction model) have been transferred, compiled, and run to completion, but work continues on fitting all the pieces of the system into the available time window within the constraint of available computing resources. (Geoff Manikin)

NCEP parallel PrepBUFR processing for the RAP running at ESRL/GSD in Boulder has been transitioned to the WCOSS. This includes non-flagged WFIP RASS and SODAR data. Changes were made to allow this processing to run in real time on the WCOSS development machine, as it is not allowed to run on the production machine. The NCO web-based RAP dump Real-Time Data Monitoring (RTDM) graphics were found to be invalid after the transition to WCOSS due to a bug in the data averaging code. This was corrected on 24 September. (Dennis Keyser)

The 2013 RTMA upgrade package has been finalized and submitted to NCO, which is setting up the pre-implementation parallels. Improved innovation statistics-based observation reject lists have been created for mesonets using localized METAR statistics as the reference. A database system has been set up to compare the NCEP and ESRL (HRRR-based) RTMA systems. Some of the shortcomings of the RTMA analysis over complex terrain and ways to address them have been discussed with team members from the Sandy Supplemental Blender Project. A job has been set up to create near real time GLERL-type pseudo wind observations from the RTMA prepBUFR file. (Manuel Pondeca, Steve Levine)

A parallel SREF has been delivered to NCO for implementation in FY2014. This bug-fix/interim upgrade includes the addition of 10 extra BUFR sounding stations requested by AWC; the reduction of low ceiling height bias seen in the two SREF NMMB_GFS members; and removes the effect of falling snow that lowers the cloud ceiling heights. (BinBin Zhou and Jun Du)

Six extra convection-related fields were added to the NCEP Storm Scale Ensemble (NSSE): probability of max updraft helicity > 25 m^2/s^2; probability of max updraft speed > 10 m/s; probability of max downdraft speed > 10 m/s; probability of max surface U and V-components > 30 knots; probability of max hourly simulated radar reflectivity at 1000m AGL > 40 dBZ; and probability of max instantaneous simulated radar reflectivity at 1000m AGL > 40 dBZ. (Binbin Zhou)

Efforts were made to find out the cause of level2 radar processing job failures during the 17 July production test on WCOSS. The job scripts were modified to exactly repeat the production run if the production level2 radar job fails. In addition, modifications were made to check for potential raw data problems. A check was added to reject a radar beam if too many “zero” values along the beam are detected. A check was added to reject a scan with fewer than 340 valid beams at that elevation angle. Checks were added for the consistency of the VCP number at different elevations, and for the header information of six radar observation variables. A memory leak was also examined in the whole level2 data processing package, and the radar data decoder was fixed. Assistance was given to NCO to set up and monitor the radar production parallel. The upgraded quality control that uses the new dual-polarity fields became operational with WCOSS on 30 July. A failed radar data processing job on WCOSS was checked in August and the memory leak in the raw data decoder causing the problem was identified and fixed. A new step was added to the radar QC package to examine test patterns in the raw data. Work was begun in September to merge reflectivity assimilation codes and scripts onto the NCEP WCOSS. GSI and forecast model codes were upgraded to use the latest version, and the NAMREF real-time parallel was set up on WCOSS to examine the benefit from assimilating reflectivity. (Shun Liu)

Work to upgrade the GSI in NDAS was done on the WCOSS computer, using a new GSI version that includes all fixes specific to WCOSS and an upgrade to use a few new types of observations. A stand-alone GSI job (using the latest CRTM library and CRTM components) was tested and run successfully on the WCOSS development machine. An NDAS parallel suite was built to test the impact of GSI code changes or use of new types of data with a relatively small amount of computer resources. The operational processing of METOP-B IASI data began in early August (but is not used in the operational NDAS). In the parallel NDAS, the increased amount of data increased the amount of run time for the regional analysis, so data thinning was turned on to decrease the run time. In preparation for the next global implementation, the NDAS hybrid analysis was tested with T575 global ensemble inputs. The sigma files were about five times larger and the run times increased by 40%, so MPI-IO will be used to speed up reading the global ensemble files. Experiments were done using different MPI processors to directly read the different components and save resources, which saved about 40% of current run time; brought the system back to roughly the operational system run time. This code will be added to the GSI for the next global implementation. Work was done to prepare and run the new GSI in the official parallel NDAS on the Zeus R&D computer system. An error was found and fixed in the code that updated the angle dependent part of the satellite bias correction. An off-line NDAS parallel was set up to test the new satellite bias correction, where 2 bias corrections of the satellite radiance currently used in many operational systems are combined and the single correction is performed inside the GSI. The new scheme performed comparable/better after an emissivity sensitivity bias predictor for sea-land differences was added. The stand-alone angle bias correction procedure was eliminated. A separate program was developed to convert the real time bias correction coefficients to the format initially used with the new scheme. (Wan-Shu Wu)

CAPS

In the last quarter, we focused on testing the capability of dual-resolution hybrid system and investigating the impacts of high- resolution analyses. Three sensitivity experiments with weighting factor to flow-dependent covariance with $1/\beta_2$ equal to 0.5 (Experiment HybridD05), 0.9 (HybridD09) and 1.0 (HybridD10) were run and compared with GSI13km (pure 13-km GSI 3DVAR experiment) and EnKFI-13KM (13-km forecasts launched from interpolated 40-km EnKF deterministic forecasts). Highest GSSs from HybridD10 verified against Stage IV data indicated the full flow-dependent covariance improve the precipitation forecast skill, although highest RMSEs verified against sounding were produced by experiment HybridD10. The sensitivity experiments to localization lengths shown that horizontal localization with 192 km, which is smaller than 40-km hybrid, is better for the higher resolution analysis, and that the dual-resolution system is not sensitive to vertical localization scale.

A dual-resolution experiment was designed to investigate the impacts of the high-resolution analysis. We replaced 13-km dual-resolution hybrid background (deterministic) forecasts with interpolated 40-km ensemble mean forecasts in all cycles (hereafter HybridRP). The forecasting results were compared with those of hybrid1WCtl (40-km 1-way hybrid experiment), Hybrid1W13 (pure 13-km forecasts launched from interpolated 40-km Hybrid1WCtl hybrid analyses) and HybridD05. All the experiments in this paragraph used half static covariance and half flow-dependent covariance. HybridRP outperformed Hybrid1W13 and HybridD05 for 0.1, 1.25 and 2.5 mm/h after 5-h forecasts, indicating the benefits of higher resolution analyses on the 13 km grid using dual resolution for precipitation forecasts. And the greater GSS of HybridD05 than HybridRP in 5 hours at 1.25 and 2.5 mm/h indicated the benefits from the high-resolution deterministic forecasts. As noticed in weighting factor tests, although higher GSS was obtained within HybridRP and HybridD05, the RMSEs verified against the sounding data from those two experiments were not as expected.

We noticed that the RMSEs against sounding data from GSI (40 km GSI 3DVAR experiment), GSIIntrp13KM (13km forecasts launched form interpolated 40 km GSI 3DVAR analyses) were comparable while precipitation from GSI13KM for 0.1 and 0.25 mm/h is clearly better too.

The general conclusion is that high-resolution analyses on the 13-km grid, either with dual-resolution hybrid, or 13-km GSI, improves precipitation forecasts, but do not necessarily improve sounding verification. In fact, 13-km forecasts starting from interpolated 40-km analyses tend to fare worse for sounding verifications for short-range forecasts.

Additional information on RAP-related tasks

ESRL

GSD continues to make pgrb and bgrb files from the ESRL/GSD RAP-primary (RAPv2) real-time 1-h cycle available from its FTP site for users in NWS and other labs)**.**

NCEP

NCEP maintained real-time availability of SAV and AHP guidance to all vendors from the operational hourly RAP on pressure surfaces via the NWS Family of Services (FOS) data feed and via the FAA Bulk Weather Data Telecommunications Gateway (FBWDTG). (EMC&NCO)

NCEP maintained real-time availability of full resolution gridded data from the operational RAP runs via anonymous ftp access via the NCEP server site at **ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/rap/prod/** and at the NWS/OPS site at **ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/** in hourly directories named MT.rap_CY.00 through MT.rap_CY.23. This includes hourly BUFR soundings and output grids, which undergo no interpolation. Both sites now contain only grids in GRIB2 format **http://www.nco.ncep.noaa.gov/pmb/docs/GRIB1_to_GRIB2.shtml.** Gridded RAP and NARRE [-TL] fields are available on **NOMADS** for the CONUS domain on 13 km grid #130 and the Alaska domain on 11.25 km grid #242. RAP fields are also available for the larger North American domain on 32 km grid #221. A limited set of fields from the RAP runs (and other NCEP models) can also be viewed at **http://mag.ncep.noaa.gov** . (EMC&NCO)

Verification of RAP

ESRL's verification of the RAP is available from **http://ruc.noaa.gov/stats**. NCEP maintained its capability and provided access to routine verifications of the operational RAP analyses and forecasts. These include grid-to-station verifications versus rawinsonde, surface, aircraft, Profiler, and VAD data computed periodically at NCEP and accessible via NCEP's Mesoscale Modeling Branch website: **http://www.emc.ncep.noaa.gov/mmb/research/meso.verf.html** .

Deliverables	**Delivery Schedule**
Task 1 – Improve turbulence guidance from NWP forecasts	
a. Finalize code for RAPv2 for implementation at NCEP (ESRL, NCEP) • Vigorous effort leading complete package with extensive improvements, summary at: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2013.pdf**	Mar 2013 **COMPLETE**
b. Complete the testing of the 40/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data (GSD, CAPS) • Initial work completed by CAPS, testing of further enhancements to system. GSD testing and inclusion in RAPv2 of hybrid system with full observational data, using GFS ensemble data. Milestones exceed.	Mar 2013 **COMPLETE**
d. Report on early version of RAPv3 primary cycle at GSD with physics enhancements for initialization of the HRRR. (ESRL)	Dec 2013
e. Report on the optimal configurations for including satellite data in the 40/13 km dual-resolution hybrid system to ensure overall positive impacts of the data (NCEP, ESRL)	Dec 2013
f. Finalize RAP version to initialize experimental HRRR for 2014 real-time use toward operational HRRR (ESRL)	Mar 2014
g. Deliver progress report on development of NARRE (NCEP, ESRL)	Mar 2014
h. Deliver progress report on ensemble/hybrid data assimilation for use in NARRE (ESRL, NCEP)	Mar 2014
i. Subject to NCEP Directors' approval, upgrades to observation processing &/or quality control and/or GSI and/or NMMB systems become Operational at NCEP. (NCEP)	Mar 2014
j. Incorporate physics and dynamics improvements from the user community, GSD, and NCEP into WRF for use in the Rapid Refresh system. (NCAR-MMM)	Mar 2014

Task 2: Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

An internal assessment of the 2013 HRRR has been completed and a summary report can be found at:

http://ruc.noaa.gov/pdf/HRRR_2013_internal_assessment.pdf.

This report provides a listing of the changes made to the RAP/HRRR system for the 2013 warm season evaluation, a performance assessment, and an overview of the run reliability and latency. Overall the change package for 2013, which also will be included in the RAPv2 and HRRR implementations at NCEP was very effective with key components including an upgrade in the RAP from a standard 3DVAR assimilation to a 3DVAR-ensemble hybrid assimilation and an upgrade in the HRRR to add a 3-km radar reflectivity assimilation procedure in addition to the 13-k m RAP radar reflectivity assimilation procedure. The overall impact from the change package was an improvement in the HRRR performance compared to 2012. Fig. 2 shows a non-matched comparison of the 2013 vs. 2012 HRRR for respective 3 month warm season periods (June-July-August 2013 vs. June-July-August 2012). While the cases and weather are of course difference, averaging of a seasonally matched long period yields a get overall estimate of the relative model performance for 2013 compared to 2012. As can be seen in the Fig. 2, HRRR forecast skill (as measured by the Critical Success Index) was better in 2013 than 2012 for all forecast lengths. The 3-km radar reflectivity assimilation led to an especially significant improvement in the HRRR analysis and carrying forward into the short-range forecast.

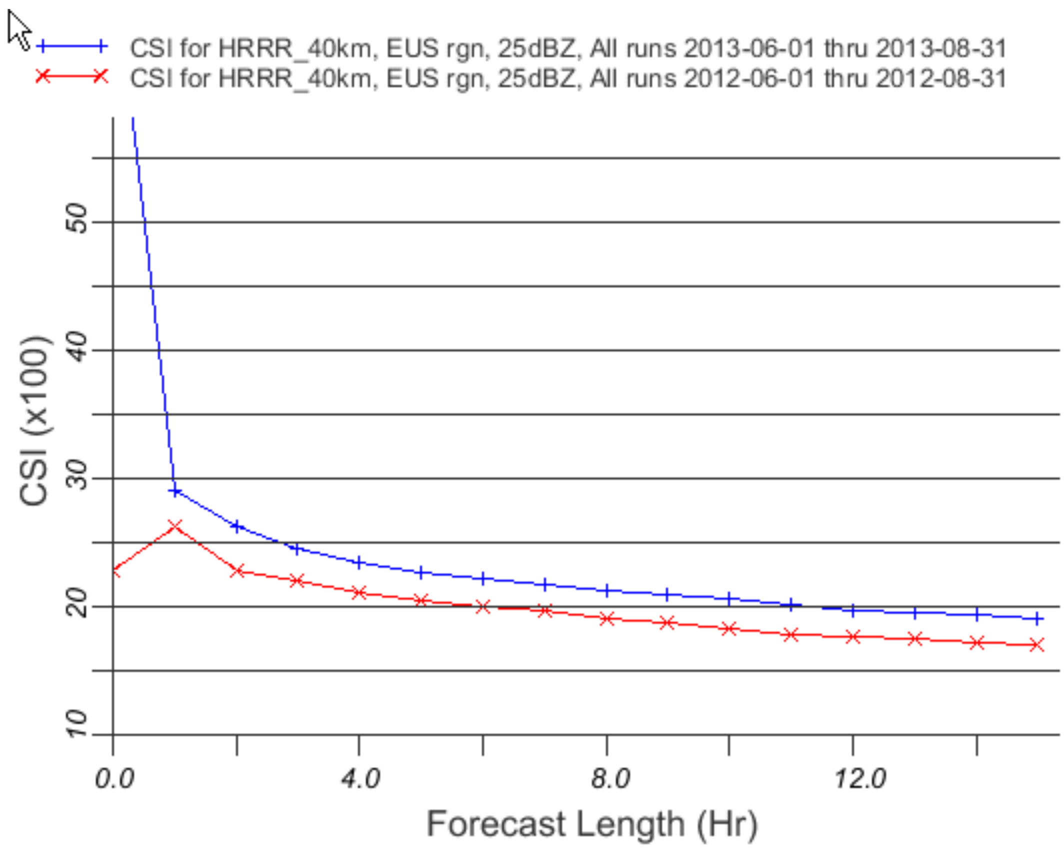


Figure 2. Critical Success Index (CSI) as a function of forecast length for 2013 vs. 2012 real-time HRRR forecast reflectivity (25 dBZ, 40-km up scaling), for respective 3 month periods (JJA (June-July-Aug) 2013 vs. JJA 2012).

In addition to providing improved forecast skill in 2013, the HRRR ran with very high reliability in 2013. As shown in Fig. 3, with exceptions for two or fewer runs (allowing for CoSPA to continue in a non-degraded mode), reliability was > 95% throughout the season. A key addition in 2013 was the dual computing system (Jet and Zeus) with failover capability as shown in Fig 3. It should be noted that the dual-system reduced the percentage of missed forecasts by about 50%. The dual-computing system was essential on some key weather days in which the Jet supercomputer system was down for maintenance. More details on both the reliability and performance aspects of the 2013 HRRR can be found in the assessment.

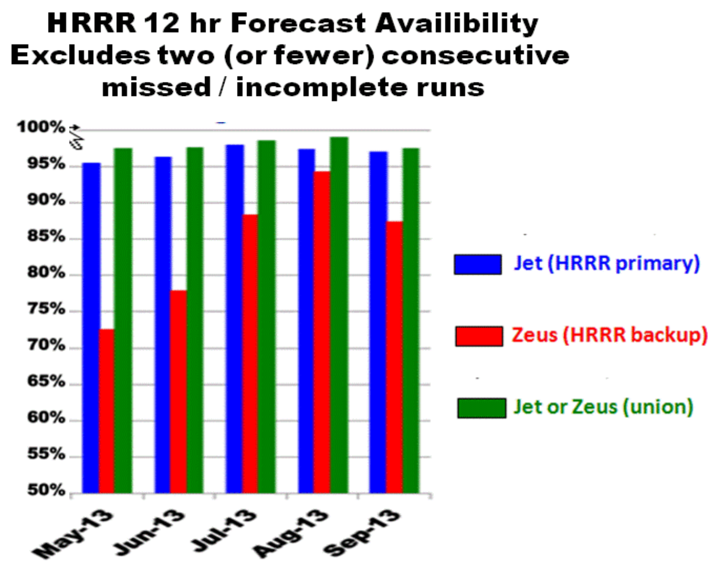
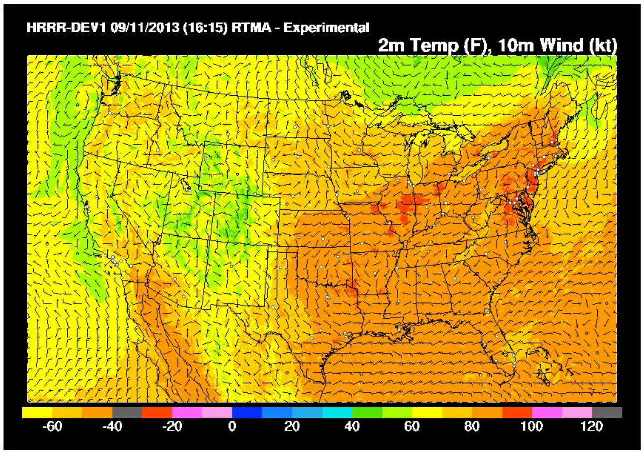


Figure 3. ***GSD Real-time experimental HRRR reliability (%) by month for period May – Sept. 2013.***

Modifications were made to the RAP-primary run by ESRL in late August and early September that modified the initial conditions for the HRRR. These changes are described under Task 1 on p.2 in this report. The WRF fixes to eliminate the error in canopy evaporation were also implemented into the HRRR.

Major work toward a carefully controlled comprehensive evaluation of the 2013 RAP and HRRR in a retrospective environment continues by Eric James in collaboration with Curtis Alexander and Ming Hu. A 2-week spin-up period has been completed (during the first half of May 2013) and a control run for the last two weeks of May 2013 is underway. In conjunction with these RAP retrospective experiments, Steve Weygandt has conducted an assessment of the combined RAP/HRRR radar data assimilation impact. His results confirm the positive benefits on HRRR forecasts for the first several hours from the 13km radar assimilation and the additional benefit from the 3-km HRRR radar assimilation for the first few hours, with a maximum benefit during the overnight into early morning hours. Additional work is ongoing to evaluate the benefit from 3-km radar radial velocity assimilation in the HRRR.

Patrick Hofmann successfully tested a prototype 15-min HRRR-based RTMA analysis, creating grids and graphics. This project involved significant work to 1) write data processing code/scripts to covert continuously updated ESRL NetCDF observation files to the GSI-required prepBUFR format with the appropriate 15-min window of data, 2) modify GSI to allow sub-hourly data processing and analysis generation capabilities, create required scripts and runtime environment to create prototype test. Sample plots of surface temperature and wind from the 15-min. HRRR-based RTMA analysis is shown in Fig. 4. Building upon the completed initial task, Patrick has extended this work by beginning to run the 15-min RTMA cycle in a real-time experimental configuration with evaluation against the GSD real-time 1-hourly RTMA. Initial results indicate that very short data cutoff time (15-min) for the 15-min RTMA is leading to a reduced set of observation and a degraded analysis. Efforts are underway to find an optimal data cutoff time to maintain timeliness of the 15-min RTMA analysis while ensuring that a sufficient number of observations are available.



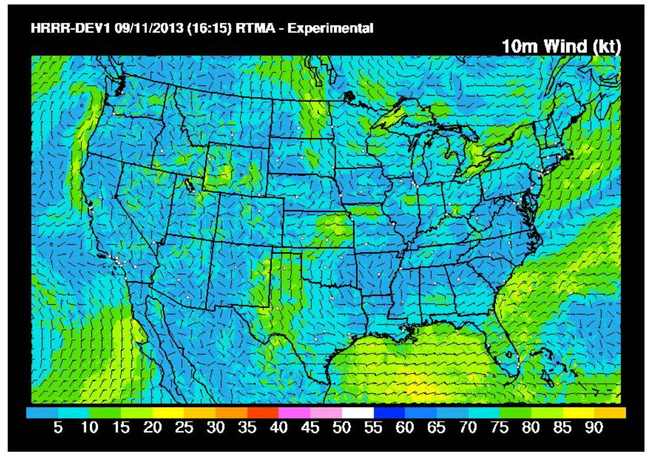


Figure 4. ***Sample graphics from prototype 15-min HRRR-based RTMA analysis for 1615 UTC 11 Sept.: 2 m temperature (left) and 10 m wind (right).***

NCEP

NCEP EMC and NCO conducted a planning exercise of what the modeling suite might look like on the Weather and Climate Operational Supercomputing System (WCOSS) Phase 1 (2013-2015) and Phase 2 (2015-2018).

NCEP & ESRL

The computing resources on NOAA R&D machine Zeus are being used by ESRL/GSD to run HRRR which together with the primary run on Jet comprise a 98.3% reliable source for HRRR.

Deliverables	**Delivery Schedule**
Task 2 – Improve Quality of Convective Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	
a. Report on initial tests of 3-km 15-min RTMA cloud / surface analysis for use in frontal diagnostics, CI assessment and other near-surface assessments (ESRL, NCEP) • *Good progress toward 3km RTMA and RUA surface and cloud analyses* • *Successful initial tests summarized in report:* **http://ruc.noaa.gov/pdf/GSD_RTMA_report.pdf**	Feb 2013 COMPLETE
b. Incorporate all assimilation and model changes that affect the HRRR into a frozen version of HRRR (and parent Rapid Refresh) for 2013 real-time use (ESRL) • *Extensive set of enhancements in place and running in real-time experimental GSD RAPv2 / HRRR system*	Mar 2013 **COMPLETE**
c. Provide preliminary 15-min RTMA surface analyses as experimental improved basis for frontal diagnostics and other diagnostics from surface analyses (ESRL, NCEP) **Prototype HRRR-based 15-min RTMA analysis completed with sample**	Aug 2013 **COMPLETE**

Deliverables	Delivery Schedule
grids and graphics.	
d. Report on computing resource status on NCEP Central Computing System, NOAA R&D Site A and NOAA R&D Site B with regards to possible implementation of HRRR (NCEP, ESRL) See above discussion concerning ~2014 implementation and Task 4	**June 2013** **COMPLETE**
e. Complete FY13 internal assessment with revised 3-km HRRR running every hour (ESRL) **Assessment complete with very good results seen for 2013 HRRR in objective and subjective verification and high run reliability**	Sept 2013 **COMPLETE**
f. Provide revised 15-min RTMA surface analyses as primary basis for frontal diagnostics and other diagnostics from surface analyses for real-time use in 2014 (ESRL, NCEP)	Feb 2014
g. Finalize all changes to the HRRR for real-time use in 2014 (ESRL)	Mar 2014

Task 3: Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE

GSD

The RAP physical parameterization configuration resulting from test and evaluation of physics options during the late 2012 – early 2013 period and described in previous reports is also what is being tested now on the NCEP WCOSS computer in preparation for the RAPv2 implementation scheduled for FY2013 Q2:

- New 9-level configuration of the RUC land-surface model (RUC LSM) with fix to canopy evaporation when the MYNN surface layer is used.
- Mellor-Yamada-Nakanishi-Niino (MYNN) planetary-boundary- and surface-layer scheme (modified considerably by Joe Olson) in place of the Mellor-Yamada-Janjic (MYJ) scheme used in RAPv1.
- Continue use of the Grell G3 scheme from WRFv3.2.1.
- Continue use of the Goddard short wave and RRTM long-wave radiation schemes.
- Use WRFv3.4.1 version of the Thompson microphysics.

As noted under Task 1, a significant bug in the canopy water evaporation was found in late August. As it turns out, the units of the canopy-water evaporation (aka latent heat flux from the canopy) are needed in different units with the MYNN surface layer as opposed to that of the MYJ, so this bug only affects latent heat flux when the MYNN surface layer is used. This removed the moist bias we had been seeing in cloudy areas in RAPv2 earlier in the summer.

With the RAPv2 going into parallel testing at NCEP during the quarter, focus in physics development shifted toward upgrades for RAPv3. We anticipate work in all aspects of the physics that will likely result significant changes for RAPv3:

- Possible replacement of RRTM long wave and Goddard shortwave radiation by the long and short wave versions of RRTMG. In addition to provision for attenuation of solar radiation by aerosol, RRTMG has a more rigorous accounting for the attenuation of solar radiation by ice and snow recently developed by Greg Thompson. Consideration may also be given to better accounting for attenuation of solar radiation by boundary-layer-driven clouds through prediction of a cloud fraction (this work leveraged from other agency funding and in collaboration with NCAR).
- Further testing of candidate LSM changes including 1) treatment of albedo in situations of partial snow cover, which itself must be parameterized, 2) reduction of surface roughness in areas of snow cover over scrubland and cropland (earlier testing on this was mostly done with the MYJ PBL and surface layers) 3) further consideration of

the representation of snow melt in low-level warm-advection conditions typical of spring.
- Further upgrades to the MYNN surface and boundary layer schemes.
- Further testing of the Grell-Freitas (G-F) convection for likely inclusion in RAPv3.
- In the next few months, testing of changes to the Thompson microphysics for WRFv3.5.1. We anticipate these will mainly impact higher rainfall rates and therefore may be of importance for the HRRR configuration in 2014.
- Likely beginning early in FY2014, but pending NCAR's preparing the code for transfer to GSD (see item a. under table of Task 3 deliverables below), test and evaluation will begin by GSD of the new aerosol-aware microphysics from NCAR. This is a potential major change and will require careful evaluation.

Some of this testing for RAPv3 is already underway, particularly for the MYNN PBL and the Grell-Freitas convection. Joe Olson has introduced some minor changes to the MYNN that decrease entrainment into the daytime mixed layer from above as part of an effort to mitigate the daytime warm and dry bias in the warm season. These are only active when there is a mixed layer. They are being tested in the RAP-dev2 cycle currently. Despite these temperature issues low-level wind forecasts in RAPv2 continue to show substantial improvement over the operational RAP, due to use of the MYNN PBL and surface layer schemes. So, we do not anticipate experimenting with other PBL and surface-layer schemes for RAPv3.

Georg Grell began actively testing the Grell-Freitas convection scheme again in September. A bug was recently discovered in the coupling between the MYNN PBL scheme and the shallow convection part of the G-F scheme, the solution of which has resulted in apparent improvement in cloud forecasts over RAPv2. Recent tests in a case study and now in RAP-dev3 are very encouraging.

The Request for Change for RAPv2 physics was completed in Sept 2013 as part of the RAPv2 implementation.
As described earlier under Task 1 efforts, NCO testing is now underway for RAPv2 on the new NCEP WCOSS computer.

NCEP

To assist GSD in fitting HRRR into the allotted computer resource (65 nodes) on WCOSS, NCEP asked an IBM Applications Analyst to look at and speed up the WRF-ARW as run in the HRRR. Curtis Alexander from GSD and Geoff Manikin from EMC have already worked with the IBM analysis, resulting in some significant speed-up. The final script configuration for HRRR on WCOSS is almost completed. (DiMego)

NCAR/RAL

CURRENT EFFORTS: In the month of September, NCAR-RAL submitted a journal manuscript to AMS Journal of the Atmospheric Sciences on the aerosol sensitivity experiments of the large winter cyclone from 31 Jan to 02 Feb 2011. NCAR-RAL reformatted the global monthly climatological GOCART aerosol data from netCDF format into WPS-intermediate format so it can more readily be included into WRF simulations. Additional code modifications for proper use of these data as input and boundary condition data was written within WRF's "real" program that interpolates the data in the vertical and prepares the lateral boundary condition data for a full simulation.

FUTURE EFFORTS: NCAR-RAL continues to coordinate with NCAR-MMM WRF code developers to ensure the simplest transfer of the new aerosol code into a future WRF release (v3.6). Once integrated into the WRF code repository, NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme. NCAR-RAL and NOAA-GSD still need to plan and carry out a method to link aerosols/species found in WRF-RAP-Chem to simplify into those variables used by the new microphysics scheme; or, alternatively, use with built-in climatological aerosols.

PROBLEMS/ISSUES ENCOUNTERED: Transfer of the code modifications of the new "aerosol-aware" microphysics scheme into a WRF code repository is a relatively large scale suite of changes but G. Thompson is actively working with Dave Gill to make this as seamless as possible. The integration of the aerosol-aware microphysics scheme depends on availability of NOAA-GSD and NCAR-RAL personnel.

INTERFACE WITH OTHER ORGANIZATIONS:
Alison Nugent (PhD student) and Ron Smith, Yale University
Yaitza Luna (PhD student), Howard University

NCAR/MMM

Deliver a WRF Users' Workshop and WRF Tutorial for the User Community

In this quarter NCAR organized and delivered a WRF tutorial at its Foothills Lab on July 15–26. This included a basic WRF tutorial, a WRFDA tutorial, a WRF-Chem tutorial, and a WRF regional climate tutorial. Approximately 60 participated, and the tutorial is described at: **http://www.mmm.ucar.edu/events/tutorial_137/index.php** .

NCAR gave a WRF tutorial in York, UK October 8–11. This is part of the NCAR–NCAS (National Centre for Atmospheric Science) 2013 Workshop and Tutorial. This covered the basic WRF, but not include WRFDA. A WRF-Chem tutorial was also presented, led by Steven Peckham of NOAA/GSD.

UPDATES TO SCHEDULE: NONE

NCAR prepared and issued minor release WRF V3.5.1. This contained a range of bugfixes and tweaks to improve schemes. A list of all of the improvements and bugfixes may be found at: **http://www.mmm.ucar.edu/wrf/users/wrfv3.5/updates-3.5.1.html**. GSD is already testing WRFv3.5.1 for

Jimy Dudhia (NCAR/MMM) continued working with Pedro Jimenez (CIEMAT, Spain) on wind-farm parameterization improvements through modifying the Fitch method of using hub-height winds for drag effects. Jimenez's method more closely follows the Blahak original method. He has already tested and implemented this in his own version together with the more generalized method of inputting turbine response tables from the manufacturer specs. This is being prepared for WRF V3.6.

Dudhia is investigating with Matt Tastula (Univ. of South Florida) a 2-m moisture (Q2) bias seen in the MYJ PBL scheme. They have found that WRF uses an incorrect surface effective moisture over water to compute the 2-m value, where it should use the QSHLTR variable inside the MYJ surface (MYJSFC) scheme instead. This issue only affects the MYJ Q2 diagostic over water, however, no other results.

Dudhia is consulting with Mary Barth (NCAR/ACD) on a lightning diagnostic in WRF. The current implementation needs to be changed, but a better approach requires the vertical velocity maximum within some radius of a reflectivity threshold. To implement a search for this maximum may present problems in a parallel code.

Dudhia worked with Mike Barlage (RAL) on fix for a sea-ice problem in the Noah-MP LSM. The problem occurred because Real automatically assigned a sea-ice point to ice when the fraction was <0.02, while NoahMP does consider this to be a glacier, not sea-ice. The solution is to disable the Real automatic setting of sea-ice points when sea-ice fractions are present in its input. The Noah LSM does not have this issue.

Dudhia and NCAR visitor Jose Ruiz-Arias (Univ. Jaen, Spain) improved the surface solar information for WRF. They added direct-normal and diffuse outputs, while implementing a method to change the solar effect gradually between radiation calls. They also addressed ingest of aerosol optical depth (either as a 12-month climatology or as three-hourly analyses using the ECMWF MACC dataset) for use for real-time solar forecasts. Dudhia continues to work with Greg Thompson (NCAR/RAL) on how to merge his own aerosol climatology used for the Thompson microphysics package with our methods for radiation.

Dudhia worked with Ming Chen (NCAR/MMM) to test and fix the NoahMP LSM for a problem found in its use with the MYJ PBL scheme in which the MYJ produced too-little cloud in ocean areas. The source of the problem was the absence of the CHKLOWQ argument that had been removed for V3.5, and the fix was to reinstate this, but with a fixed value of 1.0. The CHKLOWQ functionality is limited to Noah and was part of NCEP's operational suite with MYJ. NCEP set this to zero for saturated lowest-level conditions, but this is not needed.

For WRF dynamics, Dudhia designed a test version of purely horizontal diffusion (diff_opt=2) that would reduce in magnitude in steep coordinate regions. This method may be useful in complex terrain, as it currently is not stable in such conditions.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP will continue into the next quarter.

UPDATES TO SCHEDULE: NONE

Deliverables	**Delivery Schedule**
Task 3 – Improve Quality of Icing Weather Forecasts from RAP, HRRR, NAM, NAM-nests and, eventually, NARRE and HRRRE	**Delivery Schedule**
a. Complete initial evaluation of aerosol-aware microphysics in RAP real-time cycling at GSD for its suitability as part of the RAPv3 prototype for 2014 NCEP implementation (NCAR-RAL, ESRL)	Delayed until Feb 2014
b. Final model physics code transfer complete to EMC for Rapid Refresh 2 upgrade change package to be implemented at NCEP by spring 2014 (ESRL, NCEP) • Freeze of model physics code for March 2013 version of RAP at ESRL allows this milestone to be met.	Mar 2013 **COMPLETE**
c. Pending NCEP computer readiness and EMC and NCEP Center initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v2 software to NCO (NCEP, ESRL)	**Sept 2013** **COMPLETE**
d. Transfer upgraded coupled aerosol-microphysics scheme into a test version of HRRR (NCAR-MMM, ESRL)	Dec 2013
f. Finalize microphysics changes and other physics changes to improve icing forecasts for ESRL version of RAP and HRRR for 2014 real-time use (ESRL)	Mar 2014
g. Report summary of icing probability skill measures by quarter for the year. (NCEP)	Mar 2014

<u>Task 4: Develop convection-ATM-specific improvements for guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA</u>

Task 4 – Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL)

Current:

An improved retrieval in GSI of snow hydrometeors from radar reflectivity observations has been tested and will be implemented in the ESRL RAP and HRRR later this year. This improved retrieval will reduce the amount of snow mixing ratio that is specified in very cold regions of the model where low reflectivity is observed. The snow mixing ratio retrieval will be limited to a maximum value of 3 g/kg to avoid excessive snowfall in the model forecast. This change in the retrieval will continue to permit a reversible diagnostic of model reflectivity in WRF from the hydrometeors that both matches the observed reflectivity and is consistent with the model microphysics scheme (Thompson) used in the RAP and HRRR.

A format change in the radar reflectivity observational data feed received at ESRL from NSSL for use in the ESRL RAP and HRRR radar reflectivity data assimilation and forecast verification was implemented on 30-31 July. Work was completed in August to adapt the ESRL RAP and HRRR data assimilation pre-processing code and forecast verification code to the new format. The radar-based verification code was updated for real-time verification of RAP and HRRR forecasts. The radar data assimilation pre-processing code has now been tested in a parallel real-time RAP run and implementation in the primary ESRL RAP and HRRR is planned for November. An increase in the precision of the observational VIL feed from NSSL was also implemented to ensure adequate precision for verification of winter precipitation. A feed of legacy format radar data was established to maintain continuity of radar data assimilation in the ESRL RAP and HRRR until the new format can be used.

A new retrospective period from 15-31 May 2013 has been established to begin evaluation of model and data assimilation changes for the 2014 version of the ESRL RAP and HRRR. A control run for the retrospective period has been completed using the 2013 ESRL RAP and HRRR versions but also include an adjustment in soil temperature and moisture and a correction in the RUC land surface model to remove unrealistic surface evaporation flux in areas of precipitation that were not available during the real-time runs in early May 2013. The code for the WRF-ARW version 3.5.1 update including changes to the Thompson microphysics scheme and associated reflectivity, VIL and echo top diagnostics has been merged with the ESRL RAP and HRRR WRF-ARW code base in preparation for an upcoming retrospective run for the 15-31 May 2013 period.

Planned:
We plan to complete the transition to the new format radar reflectivity data feed for both the ESRL RAP and HRRR radar data assimilation.

Evaluation of ESRL RAP and HRRR model and data assimilation changes will be conduced using the 15-31 May 2013 retrospective period. An evaluation of the latest Thompson microphysics scheme in WRF-ARW version 3.5.1 will be conducted including testing and calibration of the associated reflectivity, VIL and echo top diagnostics.

Task 4 – Assess HRRR reliability and provide monthly reporting (ESRL)

HRRR Reliability for 0-8 Hour VIL/Echo Tops for July 2013

Jet
All runs: 96.4%
3 or more consecutive missed runs: 98.9% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.9%
3 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

Zeus
All runs: 84.5%
3 or more consecutive missed runs: 90.7% (most meaningful for CoSPA)
6 or more consecutive missed runs: 93.8%
11 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 98.0%
3 or more consecutive missed runs: 99.1% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.9%
3 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

HRRR Reliability for 0-8 Hour VIL/Echo Tops for August 2013

Jet
All runs: 96.2%
3 or more consecutive missed runs: 98.4% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.6%
5 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

Zeus
All runs: 91.4%
3 or more consecutive missed runs: 95.3% (most meaningful for CoSPA)
6 or more consecutive missed runs: 97.4%
6 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 98.7%
3 or more consecutive missed runs: 99.3% (most meaningful for CoSPA)
6 or more consecutive missed runs: 100.0%
2 outages of at least 3 hrs. or longer
0 outage of at least 6 hrs. or longer

HRRR Reliability for 0-8 Hour VIL/Echo Tops for September 2013

Jet
All runs: 94.9%
3 or more consecutive missed runs: 98.5% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.7%
5 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

Zeus
All runs: 83.2%
3 or more consecutive missed runs: 89.7% (most meaningful for CoSPA)
6 or more consecutive missed runs: 93.3%
11 outages of at least 3 hrs. or longer
5 outages of at least 6 hrs. or longer

Combined (Jet or Zeus)
All runs: 96.1%
3 or more consecutive missed runs: 98.5% (most meaningful for CoSPA)
6 or more consecutive missed runs: 99.7%
5 outages of at least 3 hrs. or longer
1 outage of at least 6 hrs. or longer

Task 4 – Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014

Tracy Smith is continuing to analyze results from an initial 5-day retrospective test run to evaluate the impact of the assimilation of GOES-CI cloud-top cooling rate data on RAP convection forecasts. She has computed various skill-scores and assesses individual case periods. Results continue to show slight improvement in short-convective forecasts (slightly improved CSI associated with better POD, but slightly higher FAR as well). Results (+3h forecast images and CSI scores vs. lead-time for a sample RAP forecast are shown below in Fig. 5). Work is continuing to re-run the RAP retrospective with an adjusted heating rate and to test direct assimilation of the GOES-CI fields in the HRRR.

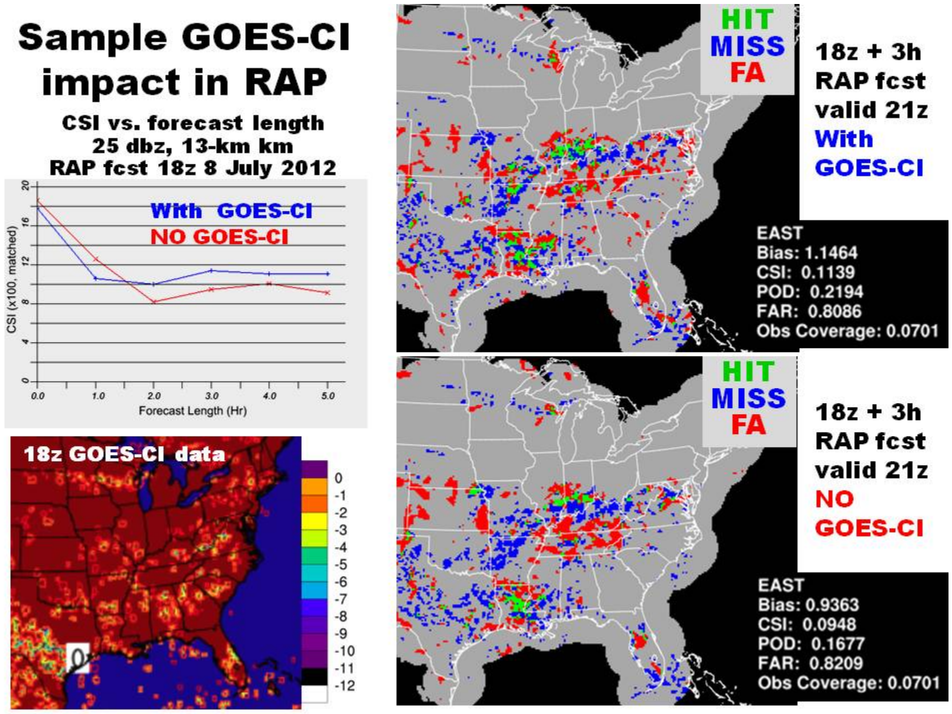


Figure 5. ***Right – Hit/Miss/False Alarm depiction from RAP +3h forecast reflectivity with and without GOES-CI (SATcast) cloud-top cooling rate assimilation for sample case (1800 UTC 8 July 2012). Left CSI skill scores vs. forecast length for this case + plots of assimilated GOES-CI data.***

Task 4 – Interact with CoSPA (or other) program partner labs and the FAA

Team (ESRL/GSD, NCAR/RAL, and MIT/LL) telecons and e-mail correspondence have and will continue to occur to discuss issues related to the HRRR reliability including scheduled outage periods during the CoSPA 2013 season. An informal discussion with MIT/LL on assessing the HRRR from an air traffic control perspective; took place on August 27. This meeting provided an opportunity to discuss possible collaboration on convective weather avoidance polygons including the potential for feedback on the evolution of the size distribution of forecasted convective structures in the HRRR. A discussion with NCAR/RAL to resolve an infrequent problem in blending the HRRR for CoSPA due to missing forecast lead times was conducted and the problem was resolved in the HRRR post-processing at ESRL/GSD.

Deliverables	**Delivery Schedule**
Task 4 – Develop convection-ATM-specific improvements to guidance from the HRRR (and later, HRRRE) and interact with CoSPA (or other) program partner labs and the FAA	
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2013 real-time use (ESRL) • Code for revised echo-top / reflectivity diagnostics with revised microphysics implemented in GSD real-time HRRR.	Mar 2013 **COMPLETE**
Conduct baseline testing of the early 2013 HRRR version (ESRL) • Baseline testing of 2013 HRRR version completed as part of code	Mar 2013

preparation for freeze. Summary of skill score improvements being prepared.	**COMPLETE**
Report on evaluation of new microphysics scheme and associated echo-top and reflectivity diagnostics in ESRL/GSD RAP and HRRR (ESRL) • *Preliminary evaluation completed and summarized in report:* **http://ruc.noaa.gov/pdf/GSD_reflectivity_report.pdf**	Mar 2013 **COMPLETE**
Assess HRRR reliability and provide monthly reporting (ESRL) Reliability statistics are being reported each month	*Apr 2013* **COMPLETE** *(ongoing)*
Report on evaluation of revised WRFv3.4 microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR (ESRL)	Mar 2014
Complete implementation of new microphysics for associated reflectivity echo-top diagnostics for 2014 real-time use of HRRR (ESRL)	Mar 2014
Complete implementation of refined SatCast assimilation for HRRR for real-time use in 2014 (ESRL) **Evaluation of preliminary results**	Mar 2014 **Good progress**
Report on 2014 baseline testing of the HRRR (ESRL)	Mar 2014